Self-contained Underwater Camera for use in the Sudbury Neutrino Observatory

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The Sudbury Neutrino Observatory (SNO) is a large heavy water Čerenkov detector. Great care was taken in the manufacture, assembly and installation of the entire detector to minimize contamination of radioactive nuclei, in particular uranium and thorium chains. The original criterion for the entire SNO detector limited the surface contamination on the PMTs, Acrylic Vessel (AV) and other internal detector components to $\lesssim 50\mu g$ of mine dust. Intrinsic contamination on detector components was similarly controlled and monitored. In particular the criterion for the bulk acrylic used in the AV was [Th,U] $\lesssim 2ppt$. These criteria were finally confirmed *in situ* using the Čerenkov light generated by these radioactive decays. In addition the light and heavy water has been assayed with *ex situ* radio-assay techniques, which strongly confirm that the levels of U and Th in the water are at or below the criteria. The AV appears to be a particularly successful construction in regards to contamination. Despite the extended construction period required by this unique vessel, *ex situ* analyses of the bulk acrylic, tape lifts of the surface contamination, and *in situ* analyses all suggest that the level of contamination in and on the AV are well below the original criteria. It has been noted in early NSD reports and in SNO presentations that a small localized spot of contamination has been identified on the AV. This spot or *blob* is directly beneath an access port leading from the cavity deck, through the PMT Support Structure and into the light water region above the AV and above the *Berkeley Blob*. This port is one of six designed into the PMT Support Structure to permit the introduction of calibration sources into the light water region. *In Situ* analyses suggest that the level of contamination in the *blob* is the equivalent of $\sim 10\mu g$ of Th. This quantity of contamination is well below the original specifications for the bulk material. The collaboration has, in fact, used the contamination as a calibration device to monitor the constancy of day and night signals in the detector.

The origin of the *Berkeley Blob* and its make-up have stimulated a large amount of discussion within the collaboration. Its location beneath the calibration guide tube are suggestive that contamination somehow was introduced through the guide tube and settled on the AV despite the use of covers on and extensive cleaning of the AV.

The Berkeley Group suggested that the deployment of a underwater camera might help some of the questions surrounding the *blob*. We identified FireflEYE camera [1] as a particularly cost-effective solution to SNO's underwater, clean, and dark environment. The camera is a 500 line 1/4" color CCD camera encased in clear epoxy. The camera contains a ring of 10 LEDs to provide illumination. A simple umbilical provides power and signal feeds to and from the camera. SNO interfaced the camera to our standard source umbilical for cleanliness reasons and deployed it down several guide tubes. While the images are still being analyzed it appears that the blob may be due to a small quantity of surface contamination on the AV.

The FireflEYE encapsulated camera is illustrated in Figure 1

FIG. 1: The FireflEYE camera deployed in SNO. The camera is waterproof, fixed focal length, and high resolution. The color 1/4" CCD provides ~ 500 lines resolution and is pressure tested to 30**m** . The unit contains 10 LEDs to provide illumination.

[1] http://www.inuktun.com/products/